Acoustic Communications Measurement System (ACOMMS)

200 dB source transducer and V-fin towbody

FUNCTION: Designs and develops adaptive signal processing techniques to improve underwater acoustic communications. Specific signal patterns are transmitted from NRL's acoustic projector source through the underwater medium to NRL's receiver array. Received signals are processed using a joint adaptive decision feedback equalizer and phase-locked loop algorithm. Improved signal processing techniques are developed and refined to minimize the bit error rate and to evaluate environmental influences on the processor's performance.

INSTRUMENTATION: Source components include: CD player, power amplifier, step-up transformer, transducer, and towbody. Receiver components include: custom designed 16-channel hydrophone array, signal processing electronics, and data monitoring and recording equipment.

DESCRIPTION: Presently, acoustic communications research is conducted at mid frequencies (<10 kHz) and high frequencies (>10 kHz). Source signal patterns designed by NRL are burned onto CD-ROMs and played on a commercial CD player. A power amplifier increases the drive up to 2,000 W and is coupled to the projector via a custom-designed matching transformer. Special cables connect shipboard drive electronics to the projector, which is mounted in a towbody that trails below and behind the ship. Source levels as high as 200 dB re 1 µPa are transmitted through the underwater medium and received at a custom-designed hydrophone array. Relative position, speed, and depth of the projector and receiver array are carefully controlled throughout the experiments. The receiver system is based on a linear array of 16 elements vertically suspended in the water column. Shipboard electronics amplify the weak hydrophone signals and condition them for digitization and recording. Custom-designed software is used for onboard data monitoring and signal processing. In the laboratory, advanced signal processing algorithms are applied to the recorded signals to extract the phase-encoded bit patterns and to improve communication accuracy.

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Instrumentation Suite for Making Measurements of Acoustic Propagation in Complex Shallow Water Environments

RF-telemetered receiving array (left) and an autonomous sound source (right) being deployed in the ocean

FUNCTION: Obtain at-sea measurements to test theoretical and modeling predictions of acoustic propagation in dynamic, inhomogeneous, and isotropic shallow-water environments. The theories and models predict variations of signal amplitude, coherence, and travel time due to interaction of sound with small to large-scale volume inhomogeneities within the water column and ocean sediment. The instrumentation suite provides calibrated measurements of these quantities in the frequency range 50 Hz to 20 kHz.

INSTRUMENTATION: As currently configured, the internally recording receiving system has a 96-element bottom-laid horizontal array and two vertical arrays having 32 and 64 elements. The vertical arrays are equipped with 2-D tilt sensors and depth sensors whose data are recorded with the acoustic data.

DESCRIPTION: The instrumentation suite includes battery-operated receiving systems and sound sources that are capable of autonomous operation. All timing functions, including acoustic transmission scheduling, waveform synthesis, and sampling of the received signals, are controlled by clocks having rubidium-standard accuracy. This feature permits measurement of absolute travel time and its variations to millisecond accuracy over the period of a month. An internally recording receiving system records up to 128 channels simultaneously, with 2.2 TB data storage capability. Transmission and signal recording functions can be programmed without the loss of timing accuracy. Since this system has no ocean surface expression, it can function during rough ocean conditions. A second receiving system, which simultaneously acquires 32 channels of 50 to 2000 Hz acoustic data, pictured on left above, telemeters digitized data to a recording station at typical ranges of 10 km, usually aboard a ship.

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Structural Acoustics In-Air Facility

Structural Acoustics In-Air Facility

FUNCTION: Supports experimental research where broadband acoustic radiation, reflection, transmission, and surface vibration measurements are required. Typically, ultrahigh precision, highly spatially sampled measurements are conducted on scaled submarine structures, satellite payload fairings, active and passive material systems for sound control, and new transducer and sensor systems.

INSTRUMENTATION: Broadband source/receiver systems; large workspace (3-D) robotic scanners for NAH; scanning laser Doppler vibrometry (LDV); multiple workstations to support acquisition, analysis, calculations, and visualization; and structural acoustic codes: SARA2D, SARA3D, AXAR, NASHUA, and SONAX.

DESCRIPTION: The large, acoustically treated facility is 50 × 40 ft and 38 ft high. The laboratory is instrumented with precise acoustic and vibration measurement systems. These include large workspace robotic scanners capable of generating near-field acoustic holography (NAH) radiation, reflection, and transmission databases. In addition, three-axis laser vibrometers are used to generate very highly sampled surface vibration maps.

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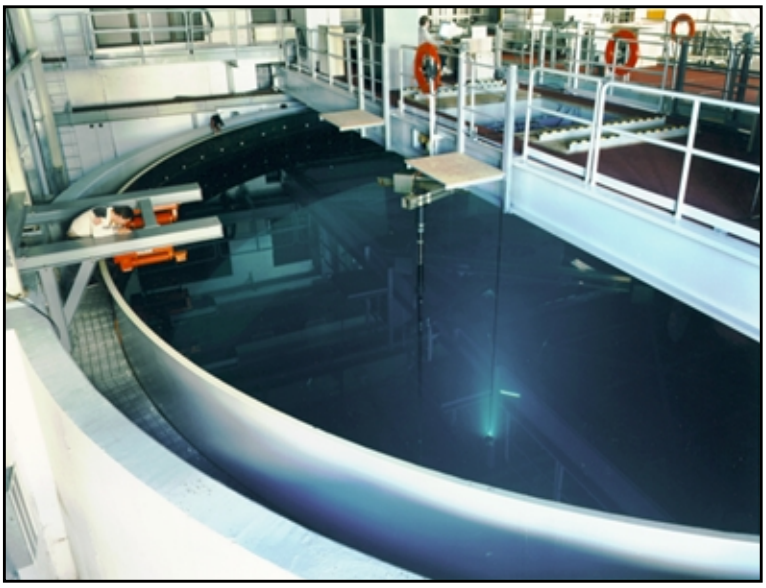
Laboratory for Structural Acoustics



Laboratory for Structural Acoustics

FUNCTION: Supports experimental research where acoustic radiation, scattering, and surface vibration measurements of fluid-loaded and nonfluid-loaded structures are required. Typically, ultra-high-precision measurements are conducted in this pristine laboratory environment using submarine hull backing impedance simulators, torpedoes, scale-model submarine structures, and deactivated mine targets.

INSTRUMENTATION: Networked-based automated data acquisition and process control including extensive use of robotic scanners. Other attributes and resources include: compact measurement ranges using nearfield sources and receivers; multiaxis Doppler vibrometers for non-contact surface motion measurements; extensive interferometric fiber optic sensor instrumentation; a 64-channel Motorola DSP 96002 matrix processor that supports MIMO control applications using state space FIR, IIR, or adaptive controllers; multiple workstations to support acquisition, structural acoustics calculations, and visualizations; a file server with more than 500 GB of storage; and structural acoustics codes: SARA2D, SARA3D, AXAR, NASHUA, and SONAX.

DESCRIPTION: The large acoustic tank, the core research capability for in-water structural acoustics studies, is 55 ft in diameter, 50 ft deep, and contains 800,000 gal of deionized water. The entire tank is vibration and temperature isolated. The laboratory is instrumented with precision measurement systems that include large workspace in-water robotic scanners capable of generating nearfield acoustic holography (NAH) radiation and scattering databases.

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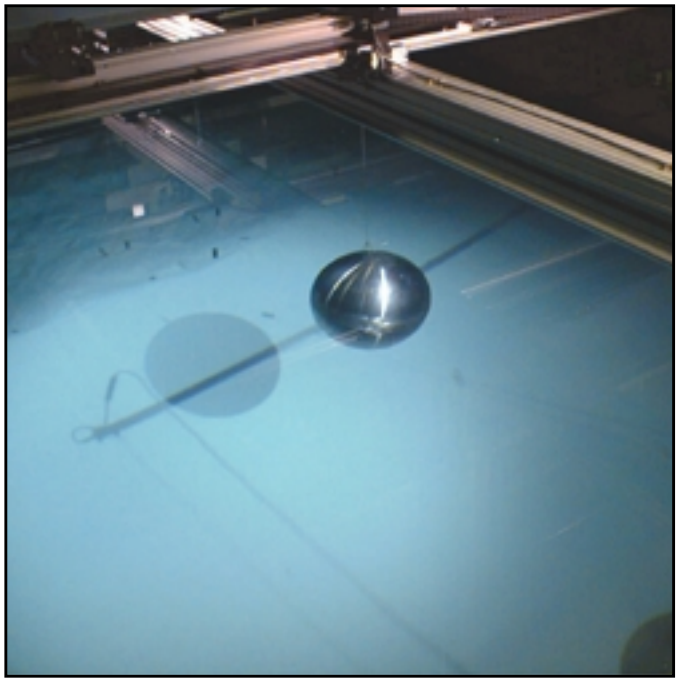
Shallow Water Acoustic Laboratory



Shallow Water Acoustic Laboratory

FUNCTION: Supports experimental research where high-frequency acoustic scattering and surface vibration measurements of fluid-loaded and nonfluid-loaded structures are required. Typically, ultra-high-precision measurements are conducted in this pristine laboratory environment when acoustic interactions with sediments are important.

INSTRUMENTATION: Networked-based automated data acquisition and process control including extensive use of robotic scanners. Other attributes and resources include: broadband source/receiver systems; compact measurement ranges using near-field sources, receivers, and projection algorithms; multiaxis Doppler vibrometers for noncontact surface motion measurements of porous media water interfaces; multiple workstations to support acquisition analysis, calculations, and visualizations; structural acoustics codes: SARA2D, SARA3D, AXAR, NASHUA, and SONAX.

DESCRIPTION: This facility includes a large concrete pool (250,000 gal of deionized water) equipped with high-resolution, computer-controlled target source and receiver manipulators. It is used for high-frequency acoustic scattering characterization of scale-model submarines and deactivated mine targets. The pool bottom has a deep, sandy bottom and a high-resolution Cartesian nearfield acoustic holography (NAH) scanner to accommodate the controlled acoustic study of buried and near-buried mines.

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Multichannel Acoustic Data Processing Laboratory

Multichannel Acoustic Data Processing Laboratory

FUNCTION: Study signal and noise characteristics and their effects on both active and passive sonar systems. The facility provides researchers the flexibility to process and analyze data from existing, prototype, and experimental sonar arrays and to implement and test advanced signal processing algorithms for Navy implementation.

INSTRUMENTATION:

- Primary data acquisition system
  - Motorola PowerPC 604 single-board computer
  - Pentek Model 4270 Digital Signal Processor with quad TI C40 processors
  - 100 Mb/s Ethernet interface
  - VxWorks real-time operating system
- Primary data processing system
  - Silicon Graphics Octane workstation with dual R12000 processors
  - 1 GB main memory
  - 200 GB disk storage
  - 100 Mb/s Ethernet interface

DESCRIPTION: The laboratory houses a network of computers designed to process and analyze multichannel acoustic data collected at sea. Capabilities include VME-based data acquisition systems and UNIX workstations with high-speed 3-D graphics connected to a Fast Ethernet local area network. Data acquisition systems feature a real-time operating system, digital signal processor boards, and high-speed disk storage. The system accepts analog or digital data from a wide variety of sources and can apply a variety of signal processing algorithms.

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Autonomous Acoustic Receiver (AAR) System

Large (10-ft diameter) buoy at sea, configured with a 0.6-m dish for satellite link to NRL

FUNCTION: Collects underwater acoustic data and oceanographic data. Data are recorded onboard an ocean buoy and can be telemetered to a remote ship or shore station in real time. The system can be configured with a satellite link for command-and-control and data down-load. It can operate unattended for periods of up to one month.

DESCRIPTION: The heart of the system is the data acquisition unit (DAU) containing the analog-to-digital converters for 64 channels at rates up to 8192 samples per second. One 64-element or two 32-element acoustic receive arrays can be attached to this DAU: if used vertically, there is also capability to add four tilt/head/depth sensors spaced throughout the vertical array. Once digitized, the data are sent up a 2000-ft fiber optic umbilical cable to a surface buoy, where it is stored on hard disk. The data can then be telemetered to another location, with an option to use a larger buoy that provides a satellite link to a receive station at NRL. The line-of-sight/ satellite link can also be used to send command and control information to the system.

INSTRUMENTATION:

- 16-bit, 8192 samples per second, 64-channel DAU
- 64-element, 1.25-m spacing acoustic receive array
- 32-element, 2.5-m spacing acoustic receive array
- 32-element, 5-m spacing acoustic receive array
- 2000-feet fiber optic double-armored umbilical cable
- Large (10-ft diameter) buoy with satellite receive and transmit capability and limited line-of-sight capability (power provided by battery/diesel-electric system)
- Small battery-powered buoy with enhanced line-of-sight capability
- Command-and-control/data downlink station with GPS-linked steerable, directional antenna (for remote ship or shore station).

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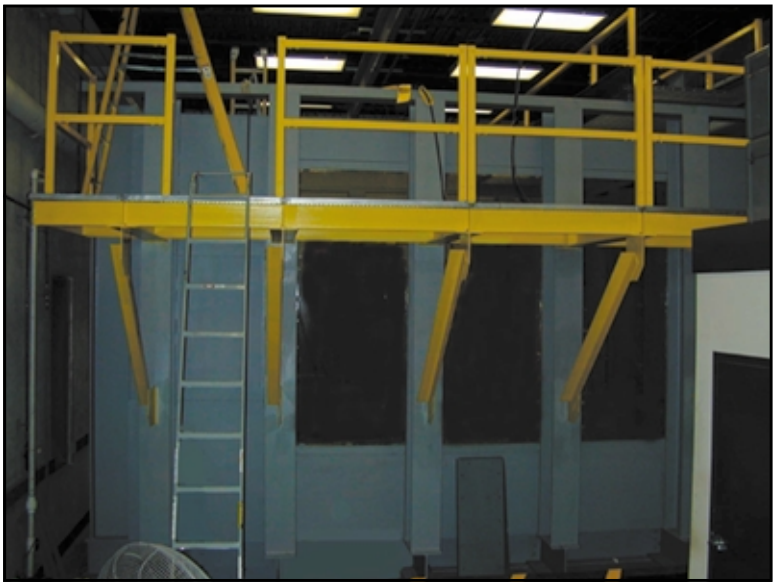
Salt Water Tank Facility



The main salt water tank provides excellent optical access to the controlled saline environment

FUNCTION: Provides a controlled environment for studying complex bubble-related processes found in the ocean. It is an experimental pool facility for studies of underwater acoustics, fluid dynamics, and air-sea interface environmental topics, under saline conditions. This facility is currently being used to study the acoustics of bubbly media.

INSTRUMENTATION:

- Acoustic sources, amplifiers, and hydrophones spanning 1 Hz to 700 kHz
- Environmental sensors to measure water temperature, salinity, dissolved gas concentrations, and surface tension
- Digital holographic imaging system to size particles down to ~5 μm
- Two high-speed digital cameras providing image acquisition up to 2000 full frames per second
- LabVIEW-based data acquisition system with Fibre-RAID storage and laboratory-wide network access
- Brickwall filters, digital and analog oscilloscopes, data loggers, power supplies.

DESCRIPTION: The main salt water tank measures 20 × 20 ft square × 12 ft high, with four 12 × 8 ft windows on each of the vertical walls. The water is recirculated every 10 h through particulate and UV filters, and the tank contains a high-capacity water chiller for controlling temperature. A separate chiller independently handles the air temperature. Catwalks and a gantry provide access around and over the main tank, and a three-axis computer-controlled positioning system with four independent stages places and moves equipment within the tank. The tank is contained within a thermally insulated 50 × 26 ft laboratory area furnished with an overhead crane, a staging area, and a 20 × 10 ft room for instrumentation and data analysis.

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Tactical Oceanography Simulation Laboratory and Wide Area Network (TOSL/TOWAN)

The Tactical Oceanography Simulation Laboratory and Wide Area Network (TOSL/TOWAN)

FUNCTION: The Tactical Oceanography Simulation Laboratory and Wide Area Network (TOSL/TOWAN) form a modeling and simulation architecture. It consists of a set of tools that provide exact recreations of oceanography, bathymetry, geophysical, and acoustic data-coupled sensor system characteristics. TOSL/TOWAN features a high-performance data delivery and computational capability to provide real or near-real-time calculations in support of science and technology initiatives as well as training, war games, operations rehearsal, and other distributed simulation functions.

DESCRIPTION: TOSL/TOWAN is nonportable. The total facility consists of dedicated classified and unclassified space and an accompanying suite of equipment to equally support both environments. TOWAN consists of two Silicon Graphics Challenge S server systems, each attached to an external disk tower for mass storage, access, and retrieval. The TOSL consists of multiple high-end visual workstations, a multiple and parallel processing capability, and data analysis tools fully connected to the environmental data repository. Replica capability exists in both a classified and unclassified environment. Unclassified access is provided via T-1 network capability, and classified access is provided via SIPRNET. Numerous other dedicated workstations, along with peripheral equipment including scanners, digitizers, and multiple color and black-and-white printers, are contained within the facility.

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Shallow-Water High-Frequency Measurement Systems

Shallow-Water High-Frequency Measurement Systems

FUNCTION: Supports a broad range of shallow-water high-frequency research programs. Those objectives range from acquiring a fundamental understanding of the physics of shallow-water propagation and boundary interactions to applied mine countermeasure and torpedo issues. The development of these systems has made NRL a leader in high-frequency shallow-water environmental acoustics research. Scattering and propagation measurements have been conducted in areas that ranged from the Gulf of Mexico to the Mediterranean. The data have been used in synthetic aperture sonar and torpedo simulations and design.

INSTRUMENTATION: These systems include high-resolution source and receiver combinations that operate in the shallow to very-shallow-water (7 to 30 m) coastal areas.

DESCRIPTION: These systems cover the 18 to 200 kHz frequency range. System control and data acquisition is carried by fiber optic cables that terminate in a portable instrumentation van where it is digitized and recorded on optical disks.

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